



Engines

Terminal Learning Objective


- ➔ Provided with an item of engineer equipment with a malfunctioning engine, with the aid of references, overhaul the engine so as it runs efficiently with a \pm of 5% tolerance to the criteria listed in the references. Diesel mechanics by Shultz, TM 09135A-15/1, TM 5-3810-305-24, TM 09148A-14/5, and 3306 Cat Rebuild Manual.

Enabling Learning Objective

- Provided a diesel engine with a malfunction, general mechanics tool box, special tools, with the aid of references, disassemble the engine in accordance with the applicable technical manual. (1341.3.11V)
- Provided a diesel engine with a malfunction, general mechanics tool box, special tools, with the aid of references, replace the defective components in accordance with the applicable technical manual. (1341.3. 11W)
- Provided a diesel engine with a malfunction, general mechanics tool box, special tools, with the aid of references, assemble the engine in accordance with the applicable technical manual. (1341.3. 11Y)

Enabling Learning Objectives continued

- Provided a diesel engine with a malfunction, general mechanics tool box, special tools, with the aid of references, tune-up the engine in accordance with the applicable technical manual. (1341.3. 11Z)
- Student reading assignment: Read chapters 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 of the Shultz Diesel Manual.
- There will be a written examination and hands-on examination at the end of this lesson.



Principles of Operation for Diesel Engines

Diesel Engine Terms

- ➔ Bore- diameter of the cylinder
- ➔ Stroke- the distance the piston travels from BDC to TDC.
- ➔ Engine Displacement- the volume of air that is displaced by all the pistons during one upward stroke.
- ➔ Ratio- the relation between two numbers or two magnitudes of the same kind.
- ➔ Compression Ratio- the comparison of the cylinder volume when the piston is at BDC and the volume when the piston is at TDC.
- ➔ Torque- the twisting effort applied to the crankshaft at a ninety-degree angle.

Diesel Engine Terms cont.

- ➔ Power- is the work done at any given time, or the rate of doing work.
- ➔ Mechanical Efficiency- is the difference between indicated horsepower and brake horsepower.
- ➔ Scavenging- is the forced removal of burnt gases from the combustion chamber with fresh air.
- ➔ Valve Overlap- is when both the intake and exhaust valves are open at the same time.

Some Principles Are the Same for Two and Four-stroke Engines

- ➔ Diesel engines are internal combustion power units in which fuel added to the heat of compressed air, is converted to work.
- ➔ Air alone is compressed in the combustion chamber.
- ➔ The compression ratio of a diesel engine is 16:1 or greater.
- ➔ Fuel is introduced into the combustion chamber by an injector.
- ➔ There are four sequences of events in all engines; Intake, compression, power and exhaust.

Cycles of Operation

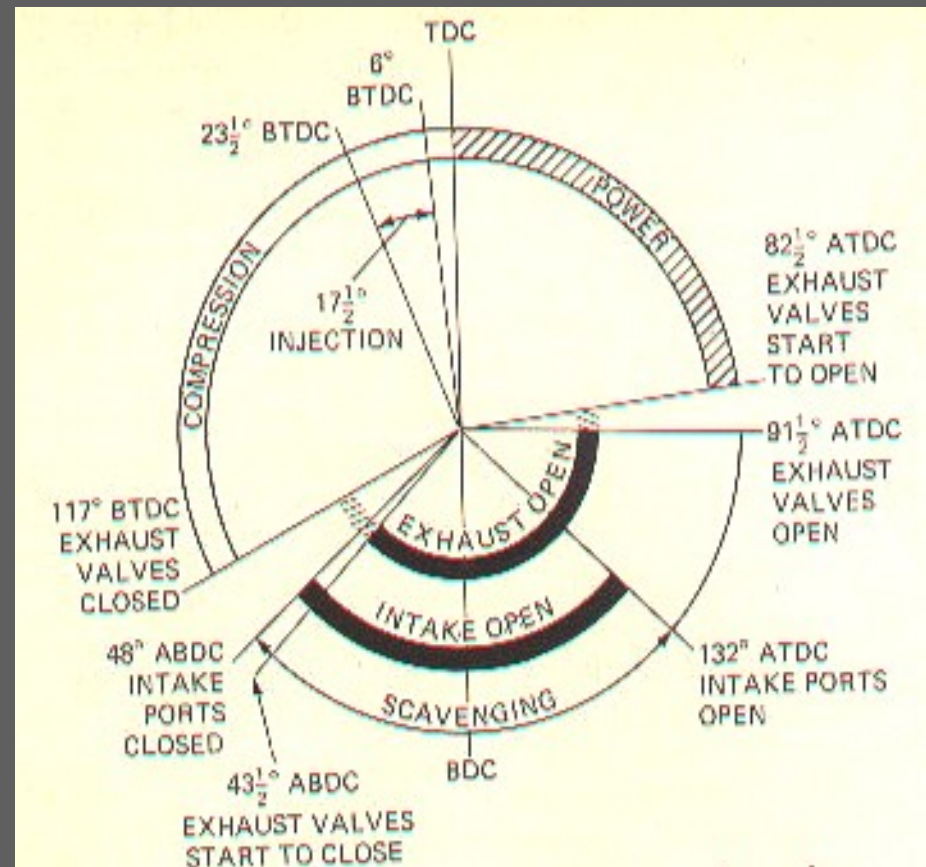
- ➡ Cycle refers to a series of events that repeat themselves
- ➡ Cycle in relation to diesel engines refer to the series of events that must occur in an engine for it to operate.
- ➡ The separate but closely related events that must occur are intake, compression, power, and exhaust.

Cycles of Operation cont.

- ➡ The cycles occur on different strokes in two and four-stroke engines
- ➡ In a two-stroke engine, all four events occur in one revolution of the crankshaft.
- ➡ In a four-stroke engine, all four events occur in two revolutions of the crankshaft.

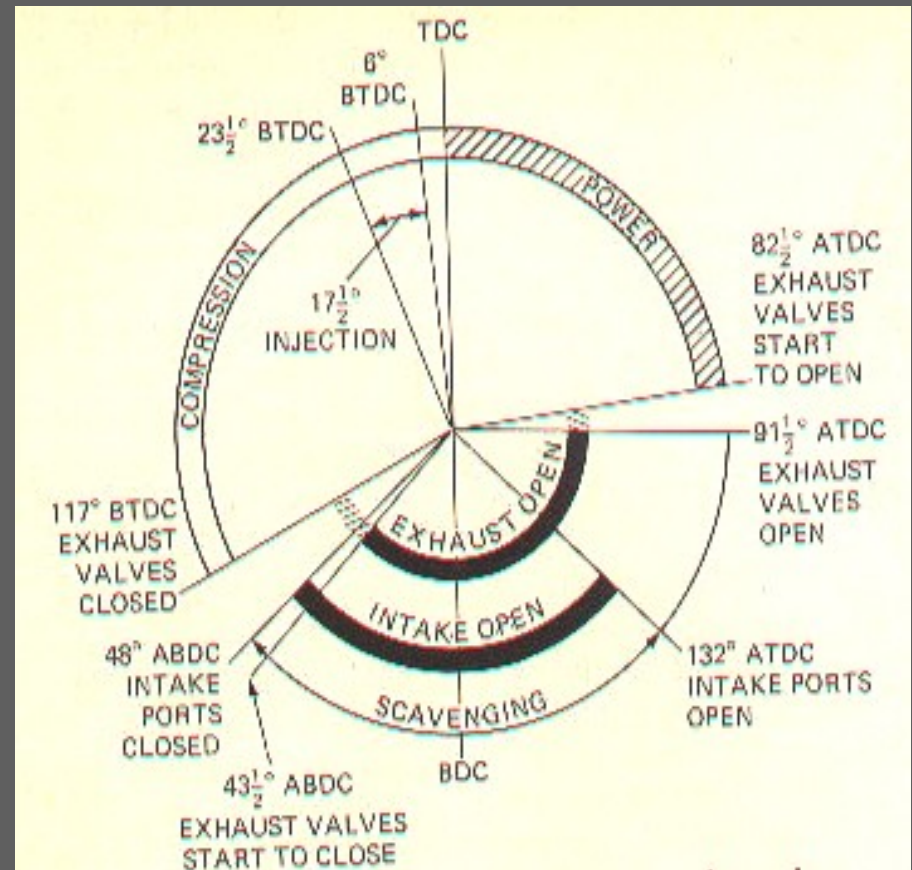
Two-stroke-cycle Engines

- ➔ Injection begins approx. 23 degrees before TDC and ends 6 degrees below TDC.
- ➔ The power stroke begins at TDC as the fuel and air ignite, forcing the piston downward.



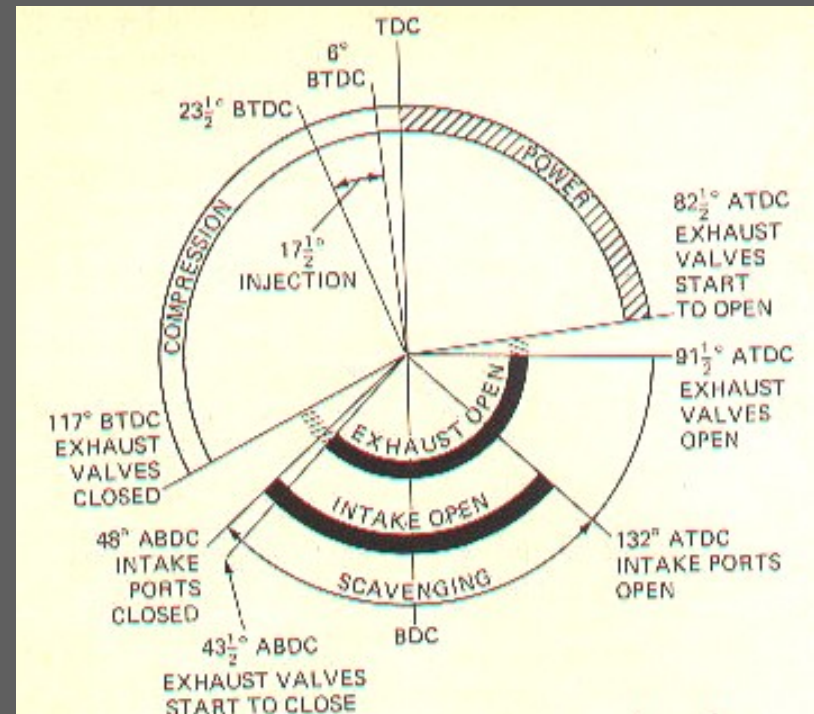
Two-stroke-cycle Engines cont,

- ➔ When the piston has moved approx. halfway down the cylinder, the exhaust valves open.
- ➔ At the same time the exhaust valves open, the intake ports on the cylinder sleeves are uncovered and the blower forces fresh air in and then out the exhaust valves.



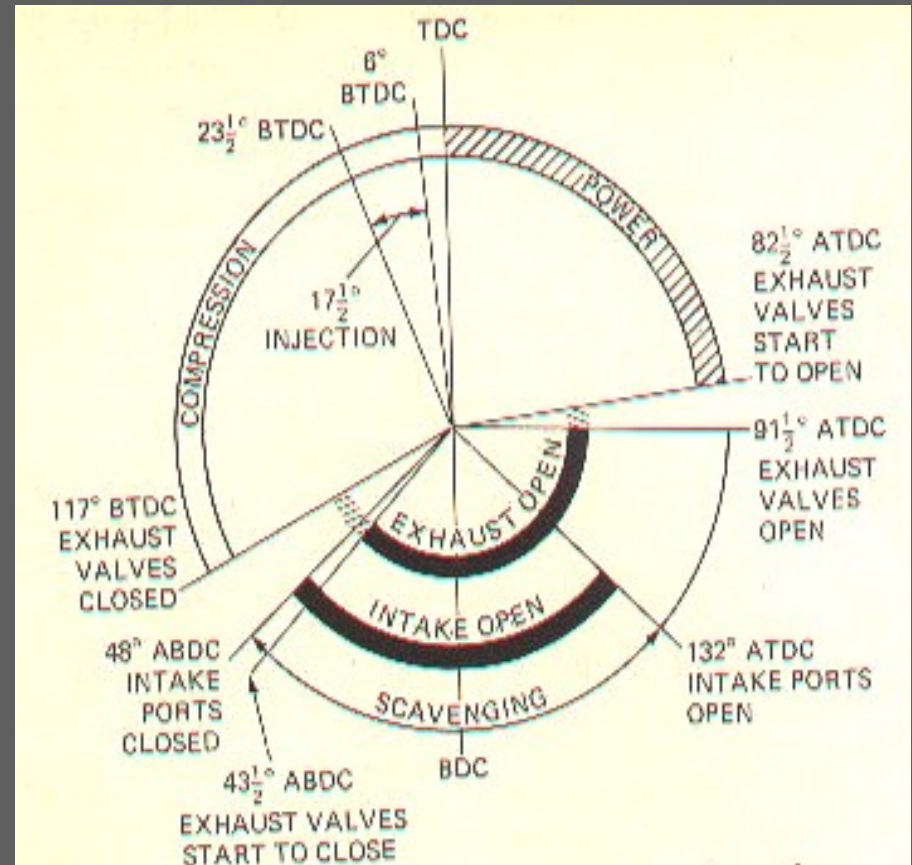
Two-stroke-cycle Engines cont,

- This is called, Scavenging
- About 44% of the working cycle is needed to remove burnt gases
- Two cycle engine requires a blower and will not work without one.
- Blower must be able to pump a large quantity of air at a pressure of 2 to 7 psi.



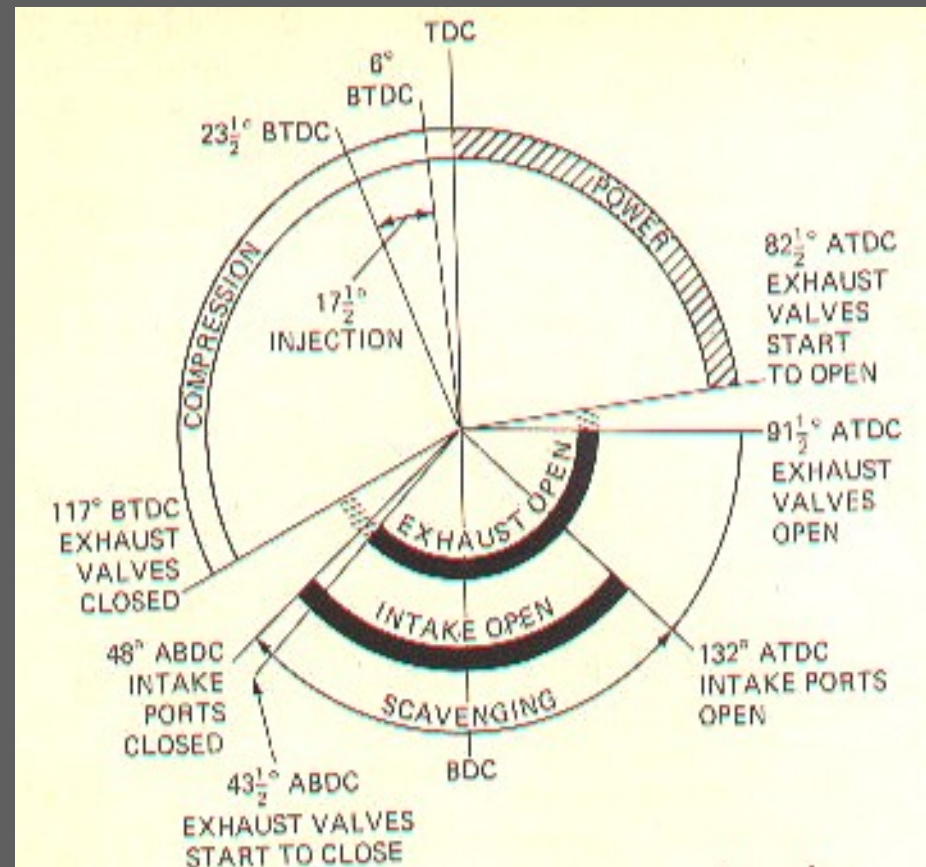
Two-stroke-cycle Engines cont,

- ➔ The piston begins to travel upward, past the intake ports, closing them 48 degrees after BDC.
- ➔ The exhaust valves are completely closed at 117 degrees before TDC.



Two-stroke-cycle Engines cont,

- ➡ The piston continues traveling upward compressing, and heating the air in the cylinder.
- ➡ Once again, fuel injection begins at approx. 23 degrees before TDC.



Two-stroke-cycle Engines cont,

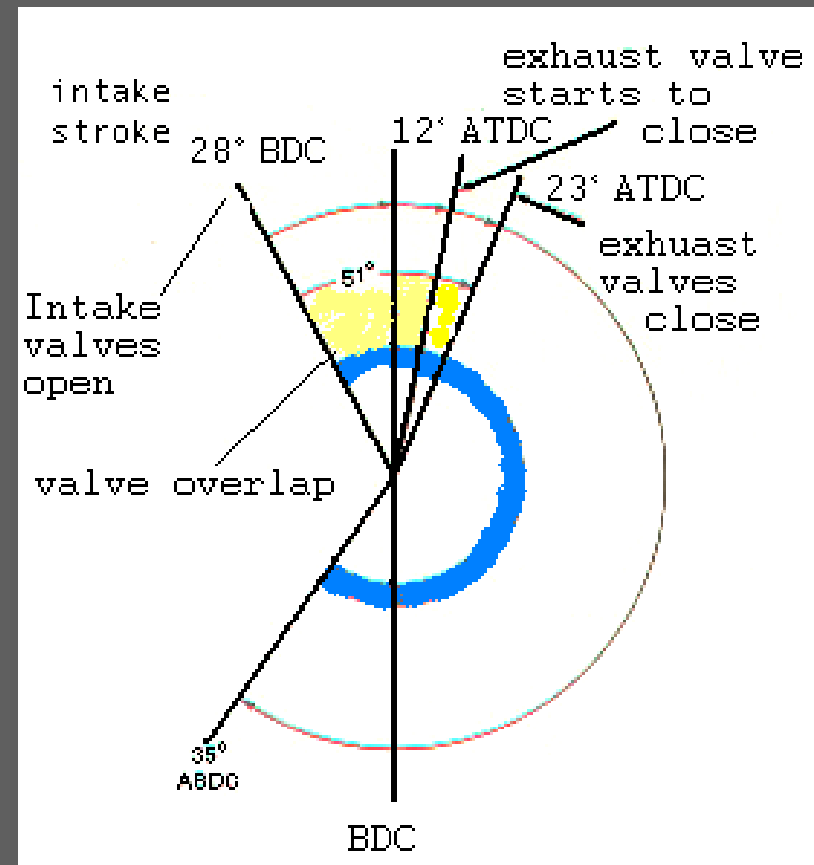
- ➔ Each downward stroke of the piston is a power stroke.
- ➔ Each upward stroke of the piston is a compression stroke.
- ➔ The intake and exhaust cycle may be considered a part of the power and compression stroke and begins after completion of the power stroke as the exhaust valves open.
- ➔ The intake and exhaust cycle ends after the piston closes off the intake ports of the cylinder liner on the compression stroke.

Four- Stroke-cycle Engines

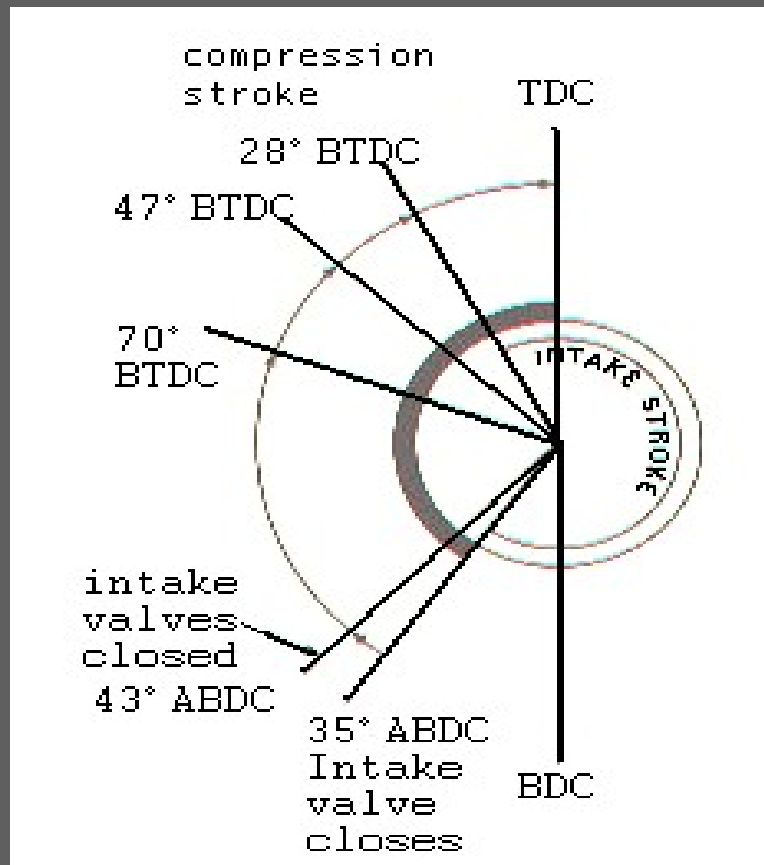
- ➡ The four stroke engine has intake valves rather than intake ports in the cylinder sleeve.
- ➡ There are considerable differences in the way four stroke engines operate compared with two stroke engines.

Four- Stroke-cycle Engines cont.

- The piston moves downward from TDC, the exhaust valve closes while the intake valve opens. Fresh air rushes into the cylinder to fill the void left by the piston.
- The piston reaches BDC and starts moving upward again. At approx. 43 degrees after BDC the intake valve closes and compression begins.



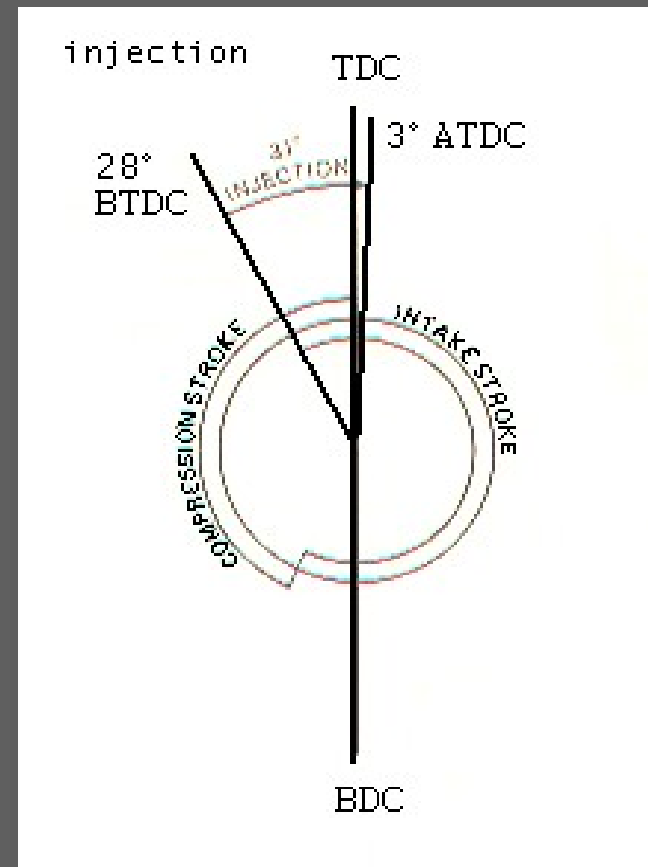
Four- Stroke-cycle Engines cont.



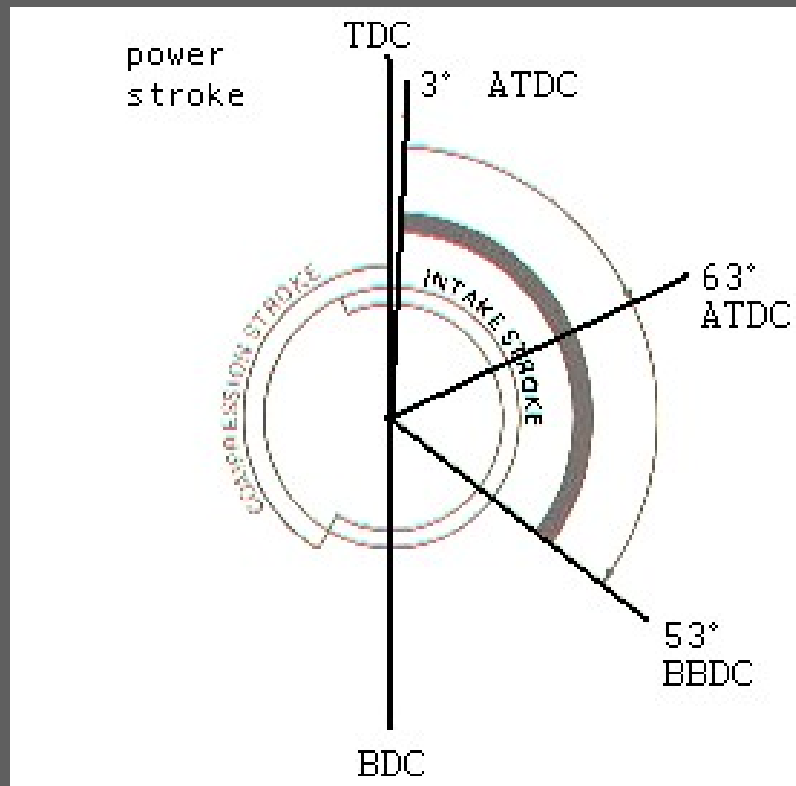
➔ The piston moves upward, compressing and heating the air in the cylinder as it does so.

Four- Stroke-cycle Engines cont.

- At approx. 28 degrees below TDC fuel injection begins.
- Because the air in the cylinder is very hot, the fuel ignites as the piston moves up past TDC, beginning its downward travel.



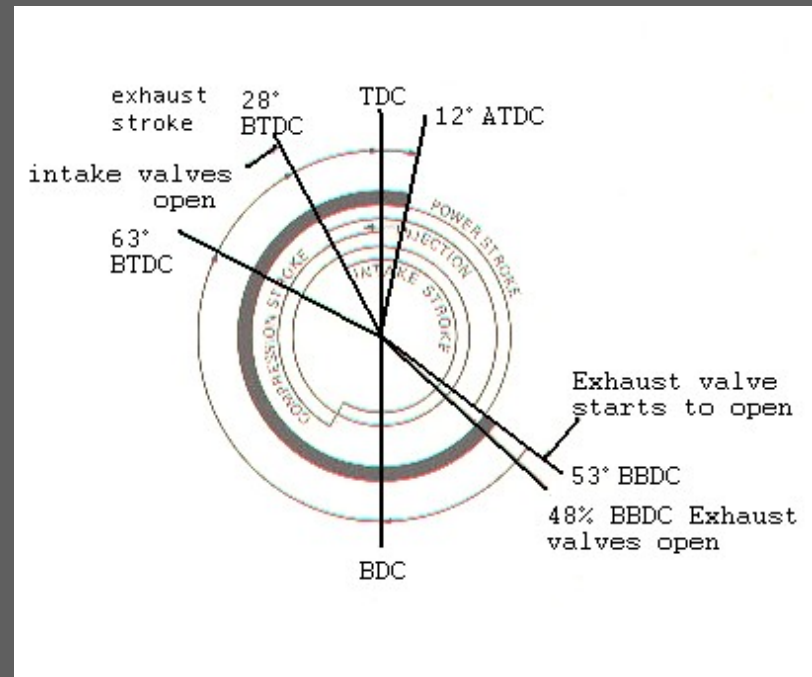
Four- Stroke-cycle Engines cont.



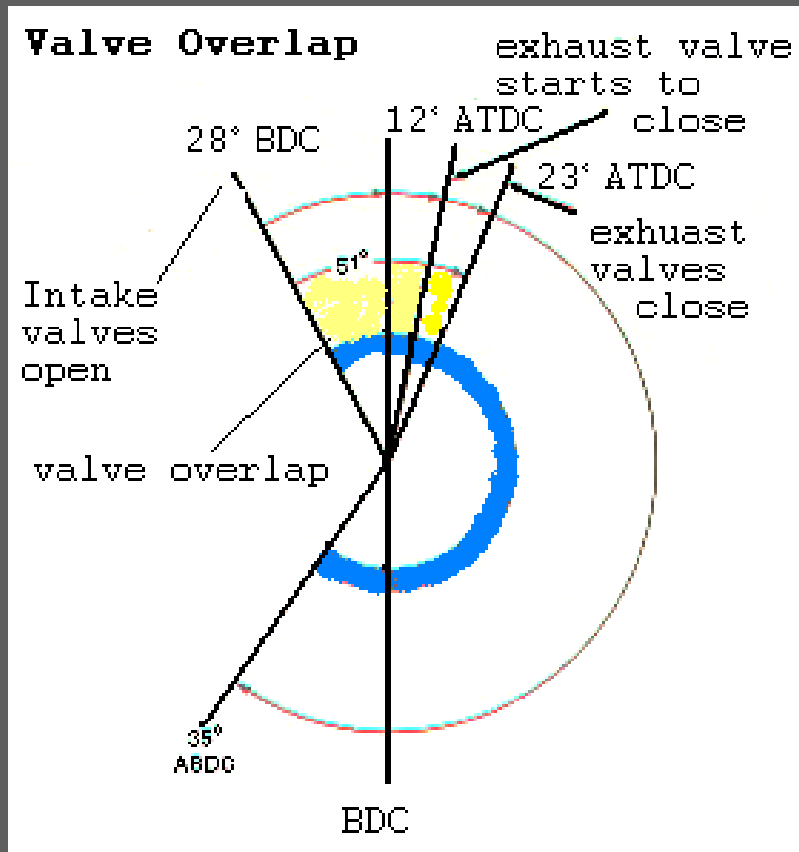
- ➔ Downward travel after the fuel ignites is the power stroke.
- ➔ It continues until the piston has moved downward to approx. 53 degrees before BDC, at which time the exhaust valve opens.

Four- Stroke-cycle Engines cont.

- ➔ At this point there is enough pressure in the cylinder to force exhaust gases from the cylinder into the manifold.
- ➔ As the piston reaches BDC and starts moving upward, the exhaust valve remains open and the upward travel of the piston continues to force exhaust gases into the exhaust manifold.



Four- Stroke-cycle Engines cont.



- ➔ There is a period as the piston nears TDC when the intake valve opens, and for just approx. 53 degrees, both valves remain open so that the cylinder is completely charged with fresh air.
- ➔ This is called **VALVE OVERLAP**, it ensures that the cylinder is purged of all exhaust gases before the intake stroke begins.

Two-Stroke Engine Heat Balance

- ⇒ The thermal distribution of a two-stroke diesel engine is about $\frac{1}{3}$ rd power, $\frac{1}{3}$ rd cooling and $\frac{1}{3}$ rd exhaust.
- ⇒ When turbocharged and after-cooled it is about 38% power, 32% exhaust and 30% cooling.

Four-Stroke Engine Heat Balance

- ➡ A turbocharged and after cooled four-stroke engine is more efficient than a two-stroke engine.
- ➡ The thermal distribution of a four stroke engine is 42 % power, 30% exhaust and 28% cooling.

3 ways Engines Dissipate Heat

- ⇒ Conduction- Transmission of heat thru matter without conducting body motion.
- ⇒ Convection- Transfer of heat from one body to another through a liquid or gas by motion of its parts.
- ⇒ Radiation- Transmission of heat in the absence of gas, liquid, or physical conductor, and by energy of the molecule and atoms undergoing change.

Relation between force and crankshaft position

- ➡ When the piston is at top dead center and a force is applied on the piston, there is no rotation, but there will be great force placed on the piston, connecting rod, bearings, crankshaft and engine crankcase.
- ➡ As the crankshaft rotates to 20 degrees after top dead center the relation between the connecting rod and crankshaft creates a 30% torque advantage.

Crankshaft position

- ➡ At about 63 degrees after top dead center the centerline of the connecting rod and the crankshaft form a 90 degree angle, thereby achieving the greatest torque advantage.
- ➡ As the crankshaft angle increases, the torque advantage decreases in proportion to that which is gained.

Supercharging

- ➔ Some of the objectives of diesel engine manufacturers are to increase engine power output(hp), increase thermal efficiency, improve reliability, and hold down maintenance cost while keeping within imposed emission standards.
- ➔ These objectives can be met by modifying air motion, fuel spray characteristics, combustion chamber configuration, compression ratio, injection timing, and fuel injection rate and by supercharging the engine.

Supercharging

- ➔ An engine is referred to as supercharged when the intake manifold pressure exceeds atmospheric pressure.
- ➔ Because the piston controls the start of compression by covering the intake ports, two-stroke engines are limited in regards to supercharging.
- ➔ Four-stroke engines do not have limitations and may be heavily supercharged.



Questions?



Take a 10 minute break

Diesel Engine Construction

Combustion chamber design

- ⇒ To achieve complete combustion, to gain power and thermal efficiency, and to stay within imposed emission standards, a maximum of inhaled air (or forced air) must be brought into contact with the injected fuel during the combustion process.

Combustion chamber design

- ⇒ In order to achieve this objective, a relatively high velocity is needed between the fuel droplets and the air.
- ⇒ The air inlet passages to the cylinder, the combustion chambers, or special chambers, are specially designed to control airflow, velocity and direction.
- ⇒ There must be no interference since this can reduce the volumetric efficiency.

Combustion chamber design

- The pressure at the beginning of combustion is also used to control airflow and velocity (squish).
- Fuel velocity is controlled through the opening pressure of the nozzle, the hole size, the spray angle, and the fuel nozzle location so that the fuel spray covers the total air flow area
- No matter which design is used, most diesel engines have oil spray tubes which direct lube oil onto the underside of the piston. This cools the piston and also helps maintain a constant combustion chamber temperature.

Various Combustion Chamber Designs

- ⇒ Combustion chambers designs may be classified as:
 - Open combustion chamber (Direct injection)
 - Precombustion Chambers
 - Turbulence combustion Chambers
 - Air cell type (Power cell or energy cell)

Open Combustion Chamber

- ⇒ In a typical open or direct injection combustion chamber the main combustion chamber is formed in the piston head, and the injection nozzle tip is positioned over the center of the piston so that the spray from the multi-orifice nozzle will be distributed evenly.
- ⇒ This spray must coincide with air movement in order to eliminate the dead air space within the combustion chamber.

Actions within an open Combustion Chamber.

- ➡ As the piston moves downward, atmospheric pressure forces air through the intake passage and promotes a circular air motion
- ➡ This circular airflow then passes through the intake valve openings into the cylinder and helps to fully charge the cylinder.

Actions within an open Combustion Chamber.

- ➡ As the piston moves up on the compression stroke, it accelerates air motion by reducing the area in which the air is rotating.
- ➡ As the piston approaches the top of its stroke, the confined swirl of air is forced into an even smaller area in the piston head. This area is an inverted cone shaped center(sometimes called a Mexican hat) that adds an even further rolling motion to the air.

Actions within an open Combustion Chamber.

- ⇒ Fuel is then evenly injected into this bowl of accelerated swirl, in four, or as many as eight directions.
- ⇒ The tip of the fuel spray hits the rim of the bowl rather than the outer circle of the piston or the comparatively cool cylinder walls.
- ⇒ The fuel forms a thin coat over the hot walls, ensuring favorable conditions for vaporization.

Actions within an open Combustion Chamber.

- ⇒ The fiery spinning vortex causes the vaporized fuel to come off the combustion chamber walls in layers, thus bringing about complete combustion.

Advantages of Open Combustion Chamber

- It has high thermal efficiency.
- All energy produced by the fuel acts directly on the piston head.
- The cylinder and piston suffer minimum effects of combustion due to the low combustion temperature.

Disadvantages of an Open Combustion Chamber.

- Emission control is difficult.
- The engine tends to run rough due to a shorter delay period. This delay causes a high and rapid pressure rise.
- It is sensitive to fuel and timing.
- The multi-orifice nozzle and high injection pressure tend to increase fuel-injection problems.

Precombustion and Turbulence Chambers.

- ➡ The injector nozzle of a precombustion chamber engine is located in a specially formed chamber that contains about 30 percent of the total clearance volume.
- ➡ Most chamber openings point toward the center of the piston

Precombustion and Turbulence Chambers.

- ➡ A turbulence chamber engine is one which has the injector nozzle located in a specially formed chamber containing about 80% of the clearance volume.
- ➡ The chamber passage is located on one side of the cylinder. Since the injector is located on the other side of the cylinder, it will not interfere with large valves. The volumetric efficiency and mean effective pressure are therefore, higher than those of the precombustion chamber.

Actions within the Precombustion and Turbulence Chambers

- ➡ On the compression stroke, air is pumped at high velocity through the restricted passage into the chamber, thus causing a high turbulence within the chamber.
- ➡ As the piston approaches top dead center, the injector discharges fuel into the chamber at a relatively low pressure.

Actions within the Precombustion and Turbulence Chambers

- ➔ Combustion then causes pressure to rise, forcing the fiery droplets, air, and gases, at high velocity into the main combustion chamber.
- ➔ Although this causes a high turbulence within the main combustion chamber, burning nevertheless is controlled by the dependency of combustion on injection.
- ➔ Controlled burning means that combustion catches up with injection and then progresses with it.

Diesel versus Gasoline Engines

- ➡ Both engines are of the internal combustion design since they burn fuel within the cylinders.
- ➡ Although they operate with the same major components, the components of the diesel engine (of equal horsepower) are heavier since they must withstand greater dynamic forces and more concentrated stress due to the greater combustion pressure.

Diesel versus Gasoline Engines

- ⇒ The greater combustion pressure is a result of the higher compression ratio:
 - In a gasoline engine the compression ratio (which controls the compression temp) is limited by the detonation and preignition quality of the air-fuel mixture.
 - In the diesel engine the compression ratio can be as high as 24:1 or as low as 14:1 because diesel engines only compress air.

Diesel versus Gasoline Engines

- ➡ The high compression ratio is one of the factors that contribute to the high efficiency of diesel engines.

Diesel versus Gasoline Engines

- ➡ Gasoline engines are self-speed-limiting because of the air intake limitations.
 - Engine speed is controlled by the butterfly valve in the carburetor, which controls the airflow into the intake manifold. In fuel injected gasoline engines, the butterfly valve in the throttle body controls the airflow.
 - The airflow meters the gasoline flow and therefore limits the engine speed. In the fuel injected engines, the airflow mass meter controls the amount of fuel injected into the manifold.

Diesel versus Gasoline Engines

- ➔ Diesel engines are not self-limiting. Intake air for combustion is not restricted, and therefore the cylinders always have more than enough air to support combustion.
- ➔ Engine speed is controlled by the amount of fuel injected into the cylinders.
- ➔ Diesel engines can accelerate at a rate of more than 2,000 revolutions per second, Therefore they require a speed limiter

Diesel versus Gasoline Engines

- ➡ Diesel engines require no ignition system because the fuel is injected (forced into the combustion area) as the piston comes to the top of the compression stroke. The fuel vaporizes and ignites as it comes in contact with the hot air, which has been compressed by the piston.
- ➡ The engines fuel system controls the quantity of fuel injected by the fuel nozzles into the combustion chamber and when the fuel enters the cylinders.

Diesel Engine Components

- ⇒ Cylinder block and Oil pan. The block forms the framework of a liquid cooled diesel engine. It is generally a single unit made of gray iron, or iron alloyed with other metals, such as chromium or nickel
 - Air cooled diesel engines usually have a separate cast iron crankcase and individual cylinder blocks.
 - The cylinder block has openings for the cylinder sleeve, oil and water passages, and bores for crank and camshaft bearings

Cylinder Block and Oil Pan

- The upper half of a water cooled cylinder block contains the water jackets.
- The lower half of the cylinder block where the crankshaft, camshaft followers, and pushrods are located is called the crankcase.
- An oil pan, which is bolted to the crankcase, forms the oil reservoir for the lubricating system

Piston and Piston Rings

- ➡ The piston and its piston rings act as a piston pump while moving up and down in the cylinder sleeve.
 - Pistons are made from aluminum and cast iron alloy.
 - Piston rings are made from cast iron alloy, and compression rings are commonly chrome plated.
 - The two main functions of the piston and piston rings are to seal the lower side of the combustion chamber and to transmit the pressure of compression and combustion via the piston pin and the connecting rod to the crankshaft. They also transmit heat to the cylinder walls and the water jacket.

Different types of Pistons

- ⇒ There are different types of pistons for 2 and 4 stroke engines.
- ⇒ Trunk type pistons are made from a malleable iron that is plated with a protective tin coating, which permits close fitting, reduces scuffing, and prolongs piston life. These type are most commonly used in 2 stroke engines
 - The top of the piston forms the combustion chamber.

Trunk type pistons

- The top of the piston is the crown and it is the thickest part of the piston.
- The top of the piston, or combustion chamber, also referred to as the swirl cup, is designed to aid in the mixing of fuel and air.
- Each piston is internally braced with fin-shaped ribs and circular struts to ensure rapid cooling of the piston crown and better heat transfer.

Trunk type pistons

- The piston is cooled by an oil spray, which is directed at the underside of the piston head. This spray comes from a nozzle in the top of the connecting rod. The piston is also cooled by the fresh air from the blower, and indirectly by the water jacket around the cylinder.
- Two bushings with helical grooved oil passages are pressed into the piston pin bosses to provide a bearing for the piston pin.

Trunk type pistons

- The piston pin boss is sealed with a steel retainer to keep oil from reaching the cylinder walls.
- The elliptical or egg shape of the piston permits it to fit into the cylinder hot or cold, and allows it to expand under heat to provide a better seal.

Cross Head piston

- ➡ A piston consisting of two pieces, a crown (top) and skirt (bottom).
 - The ring grooves are machined in the piston for a fire ring (top ring groove) and compression rings.
 - The skirt has two oil control ring grooves, piston pin bosses, and piston pin counter bores machined into the body.
 - The oil control ring grooves have oil drain holes cut into them to allow excess oil that is scraped from the cylinder walls to return to the crankcase.

Cross Head Piston

- This type of piston has a semi-floating piston pin, which means the piston pin is anchored to the connecting rod by a screw and turns in the piston pin bosses.
- This type of piston is lighter in weight and cost less to replace because it has two pieces.
- Also used in two-stroke engine applications.

Caution: Crosshead and trunk type pistons must not be used in engines together because of their weight difference.

Precombustion Chamber type Pistons

- ⇒ These types are made of aluminum alloy and the crown is flat with valve cutouts machined in them
 - It has a steel plug inserted in the crown that absorbs heat generated when the fuel is injected and burned. This steel plug prevents the hottest part of the crown from melting.

Precombustion Chamber type Pistons

- Ring grooves are all above the piston pin bosses, unlike the piston on the two stroke engine, where the compression ring grooves were above the and the oil control rings were below the piston pin bosses.

Direct Injection Type Pistons

- ➡ Made of aluminum alloy and the piston crown is concave with valve cutouts machined in them.
 - The concave top allows the air fuel injected to swirl in the combustion chamber.
 - The concave portion in the crown is the lower portion of the combustion chamber.
 - The piston pin bosses are grooved on both ends to accept retainer rings that hold the piston pin in place on both the precombustion and direct injection type pistons.

Caution!

- ⇒ Precombustion and direct injection type pistons cannot be used together in an engine.
- ⇒ The weight and crown design would cause the engine to malfunction.

Piston Rings

⇒ All pistons have two types of rings

- Compression rings.

- Top set of rings located above the piston pin bosses.
- Compression rings are made of cast iron or malleable iron with a chrome face to reduce friction and save the life of the ring.
- Aids the piston in compression and combustion.
- If the rings are marked, it means this side up to indicate the right way to install them.

Piston Rings

■ Oil Control Rings

- Used to limit the oil film on the cylinder walls and to provide adequate lubrication to the compression rings.
- On two stroke engine pistons they are located on the bottom of the piston below the piston pin to prevent burning the oil.
- On four stroke engines they are located below the compression rings and above the piston pin bosses.
- The scraper edge of the oil control ring faces downward toward the crankcase.
- All piston rings must be staggered before assembly to prevent blow-by.

Connecting rods

- ➡ The connecting rod is made of drop forged, heat treated steel and is the link between the crankshaft and the piston.
- ➡ Usually made in an I beam shape for strength and is lightweight in design.
- ➡ It is bored at each end, and in the upper bearing bore (piston-pin bore) a bushing is inserted in which the piston pin is located.

Connecting rods

- ⇒ The lower bearing bore (crankpin bore), is split in half by the connecting rod cap. The rod and cap are assembled in only one way, with the tangs on one side. This is to prevent the bearing from spinning in the bore.
- ⇒ On-half the connecting rod bearing fits tightly into the rod cap, and the other half fits tightly into the connecting rod.

Connecting rods

- ⇒ Some types of connecting rods contain a small bore which runs from the crankpin bore to the piston pin bore to allow oil to be sprayed on the underside of the piston thru an orifice that meters the flow of oil being sprayed.
- ⇒ The piston pin is cylindrical in design, case hardened, and either full floating, semi-floating or press fitted.
- ⇒ The piston pin connects the piston to the connecting rod.

Bearing types

- ➔ Bearings may be divided into two main types: friction bearings or antifriction bearings. Both types are used on diesel engines
 - Friction is defined as the resistance to movement between any two surfaces, which are in contact with each other.
 - Friction is classified into three types: sliding, rolling and fluid.
 - Friction bearing are found in the engine and its components
 - They are used to support the crank, cam, rocker arm shafts.

Bearing design and Construction

- ⇒ Bearing construction originates with a strip of steel to supply strength for the bearing back.
- ⇒ A softer metal lining is bonded to this steel strip. The softer metal is necessary to improve conformability and embedability of the bearing.
- ⇒ The most popular bearing produced are steel backed with a bronze inner layer and lead or tin-based or indium overlay.

Function of Friction Bearings

- ⇒ A friction bearing must be held firmly in place and in full contact with the supporting bore to do its job properly.
- ⇒ It must hold and protect the shaft, withstand extreme pressure and heat, and absorb harmful grit.
- ⇒ It must also have the ability to maintain a film of lubricant between moving and stationary parts.

Function of Friction Bearings

- ➔ The simplest and most common method of holding a bushing in position is to press it into its supporting bore (cam bearings). A locating lug or dowel pin is used to hold a half-bearing in place during assembly. The lug fits tightly into the support slot and thus ensures proper alignment and prevents the half-bearing from moving.
- ➔ A half bearing is manufactured with a spread and is slightly larger than the bearing bore. This is to ensure a precise fit and full contact with the bore surface when the connecting rod or main bearing cap screws are torque.

Function of Friction Bearings

- ➡ The bearing spread by which the dimension is larger than the bore varies between 0.005 and 0.030 in. depending on bore design and size. The bearing crush may be as little as 0.00025 in.
- ➡ An insufficient crush or spread allows the bearing to move in the bore, reducing heat dissipation and causing excessive wear.

Bearing Requirements

- ➡ No metal by itself has the strength to withstand all the demands placed on the bearing.
 - A bearing should have fatigue strength (load-carrying capacity) to withstand loads without the metal flaking away or cracking on the surface or bond line.
 - A bearing should have conformability since no journal or bore is perfectly round or straight. The bearing must mold itself to this imperfection so that the load is evenly distributed over the total bearing surface. A soft metal over plate and/or tin overlay increases the conformability of the bearing.

Bearing Requirements

- A bearing should have embedability, that is, the bearing surface must be soft enough to absorb minute particles. This is important feature since no filter is effective forever, and no service and maintenance procedure can completely guarantee that dirt particles cannot enter the oil to score the journal and bearing.
- A bearing should have resistance to corrosion because chemicals and water from combustion (or from other sources) enter the crankcase. The chemicals and water in the oil will attack the bearing metal if it is not resistant to them.

Bearing Requirements

- A bearing should have resistance to seizure because, under certain conditions, there is metal to metal contact between the journal and bearing. Materials used to prevent this type of failure are shown in the table in your handouts.
- A bearing should conduct heat to a high degree so that most of the heat will be conducted to the connecting rod or cylinder block. (A good bearing fit increases conductivity)
- A bearing should have a relatively high high-temperature strength; That is, its construction and composition must not weaken from heat.

Bearing Requirements

- A bearing must have oil clearance in order to lubricate properly, to cool, and to form a wedge to center the journal during rotation.

Bearing Action

- When the engine is stopped, the journal rests against the lower bearing shelf. As the crankshaft is rotated (and oil is present in the oil clearance), the journal climbs the bearing and the oil slides under the load area.
- The journal is lifted, or the connecting rod bearing is moved away from the journal, by the wedge formed from the oil molecules. Some oil molecules tend to stick to the journal and bearings. The oil molecules attached to the journal rotate with it while those on the bearing are somewhat stationary.

Bearing Action

- ⇒ The slippage of oil molecules past each other is known as fluid friction.
- ⇒ The oil film thickness between the journal and bearing is not always the same. The bearing load during the four strokes, the speed, and the load changes vary the film thickness.
- ⇒ Under extreme load conditions only the oil that sticks to the journals and bearing area remain, permitting metal to metal contact, which could lead to seizure.

Bearing Action

- ➡ Oil holes and grooves are usually placed in the lower half of the bearing. They are used to distribute oil over the total journal and bearing area.
- ➡ In some applications an additional oil groove is used to direct oil to the other bearings or to supply oil to the other components.



Questions?



Take a 10 minute break

Cylinder Sleeves

- ⇒ The cylinder sleeve or cylinder liner forms the combustion chamber walls.
- ⇒ There are two types of sleeves.
 - When the cylinder sleeve is in direct contact with the coolant it is referred to as a wet sleeve.
 - When the cylinder sleeve is indirectly in contact with the coolant, that is, the sleeve is enclosed in the cylinder, it is referred to as a dry sleeve.

Cylinder Sleeves

- ➡ It is through the cylinder sleeve contact with the coolant or cylinder block that efficient cooling is achieved.
- ➡ Wet sleeves have special sleeve seals, which seal the coolant at the lower end of the cylinder sleeve and block.
- ➡ The accurately machined surfaces of the sleeve flange, cylinder block and cylinder head gasket form the seal at the cylinder block surface (top deck).

Crankshaft

- ➡ The crankshaft converts up and down motion of the pistons into rotary motion. It ties together the reactions of all the pistons into one rotary force that drives the machine.
- ➡ The crankshaft is made from forged steel and has precision machined and hardened main bearing and connecting rod journals.

Crankshaft

- ➡ The offset cranks of the crankshaft are balanced for proper weight distribution to ensure even force during rotation. The arrangement of the offset cranks or throws affect:
 - The balance of the engine.
 - Vibration from turning of the shaft.
 - Loads on the main bearings.
 - The firing order of the engine.

Crankshaft

- Some crankshafts use counterbalance weights (or gear train) to achieve balancing.
- The shaft rotates in its main bearings and lubricating oil from drilled passages within the cylinder block feeds the main bearings.
- Drilled passages in the crankshaft pass lubricating oil to the connecting rod journals. A crankshaft thrust bearing is used to prevent excessive end movement.

Crankshaft

- ⇒ Main and connecting rod journals of most crankshafts are induction hardened. They are also ground and polished to the exact bearing size. Chrome plating of the journal is not very common, although it is one way to reclaim old journals.

Flywheel

- ➔ Mounted on the rear of the crankshaft, the heavy flywheel is a stabilizer for the whole engine.
- ➔ The flywheel serves three purposes:
 - Through its inertia, it reduces vibration by smoothing out the power stroke of the cylinders.
 - It is the mounting surface of the clutch pressure plate and the friction surface for the clutch. When a fluid clutch is used, the impeller is splined or bolted to the flywheel.
 - The “shrunk on” flywheel ring gear is used for transmitting cranking motor power to the crankshaft.

Flywheel

- ➡ In a four cycle engine, the flywheel, must be heavy enough to turn the engine during the exhaust intake, and compression strokes. At the same time, it must transmit power to the driven machine.
- ➡ The more cylinders in the engine, the less need for a flywheel. This is because the power impulses are closer together and the engine has more momentum on its own.

Flywheel

- ➡ A lighter flywheel is needed for an engine operated at variable speeds where faster acceleration is required.
- ➡ Fly wheels are generally made of cast iron or steel and are fastened to the crankshaft by dowel pins and bolts. It does place a heavy load on the engine rear main bearing, which should be checked carefully at overhaul.

Vibration Damper

- ➡ A vibration damper is a unit which counteracts the twisting or torsional vibration caused by force variations(usually from about 3 to 10 tons) on the piston and subsequently the crankshaft.
- ➡ Torsional vibration is a rhythmic force which occurs every power stroke. The application of force, and its absence a split second later, causes the crankshaft to be alternately twisted out of alignment and then snap back into place.

Vibration Damper

- ⇒ If preventive measures were not taken against this, the engine would run rough and the crankshaft could break.
- ⇒ Vibration dampers of the viscous or rubber element design are fastened to the front of the crankshaft.
- ⇒ Since torsional vibration differs with engine design, vibration dampers are constructed to suit specific engines.

Cylinder heads and valves

- ⇒ The cylinder head is cast as a one piece unit and is the upper sealing surface of the combustion chamber.
- ⇒ It may serve one, two , three, four or six cylinders, and contain two or four valves per cylinder.
- ⇒ The valve guides, which guide the valve stem during the opening and closing of the valves are pressed into the cylinder head.

Cylinder heads and valves

- ⇒ Intake valves and seats, in conjunction with the valve mechanisms, control the entry of air into the combustion chamber via the intake manifold.
- ⇒ The exhaust valves and seat, in conjunction with the valve mechanism, control and release the combustion pressure from the combustion chamber in the exhaust manifold.

Timing gears, Camshaft and Valve mechanisms

- ➡ The timing gears transmit rotary motion to the camshaft and at the same time maintain a fixed relation between the camshaft and crankshaft.
- ➡ The camshaft rotates on friction bearings in the crankcase. The camshaft turns 1 revolution to 2 of the crankshaft. The rotary motion of the camshaft is transmitted to the followers (lifters), thereby causing the followers and pushrods to move up and down, the rocker arms to pivot, and the valves to open and close.

Timing gears, Camshaft and Valve mechanisms

- ➡ On engines where the camshaft is located above the valve stem (overhead), the cam lobes open and close the valves by directly pushing each valve's cam follower.
- ➡ Unlike the two stroke engine, the four stroke engine has different configurations for gear trains, depending on make and model. Even though they are different in design, they both must keep the camshaft and crankshaft in time with each other.

Diesel engine Subsystems

➔ Diesel engines require five supporting systems in order to operate:

- Cooling
- Lubrication
- Fuel injection
- Air intake
- Exhaust

The function of each system is equally important to the engine as a whole.

Cooling System

- ⇒ The cooling system is responsible for maintaining an even temperature during operation, of about 190 degrees Fahrenheit.

Lubrication System

- ⇒ The lubrication system is responsible for supplying lubricating oil to the bearings, gears, and other components, which need to be lubricated and cooled. Most diesel engines have oil coolers to assist in cooling the oil.

Fuel Injection System

- ⇒ The fuel injection system is responsible for supplying and injecting the required amount of fuel into the cylinder, at the right time.

Air Intake System

- ➡ The air intake system is responsible for supplying clean cool air to the cylinders, for supplying air for scavenging, and for reducing the airflow noise. Two cycle engines require an additional blower for scavenging.

Exhaust System

- ➡ The exhaust system is responsible for directing the exhaust gases into the atmosphere and lowering the noise level.



Caterpillar Head Reconditioning Film

Valve Grinding film



Questions?



Take a ten minute break

Measurements to be taken

- ⇒ Fill out lab sheets for the engines you are assigned to!
- ⇒ You must use the correct TM.

Practical Application

Safety Brief

- ➡ Remove all watches and rings in shop area
- ➡ Adhere to safety at all times
- ➡ Pay attention to instructor
- ➡ All components to be measured will be cleaned and in one area of the shop